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Abstract

This study shows the influence and interrelations of bruising level, temperature and soaking time on product yield and pitter efficiency of tart cherries. Variations of firmness and soluble solids were also measured to study their relation to product yield and pitter efficiency.

Studies conducted on fruit held at 54°F in commercial soak tanks indicate that in 1966 product yield and pitter efficiency were optimized after 4 to 6 hours of soaking for most bruise levels. The effect on product yield resulting from using 39°F soaking tank temperatures was also investigated.

Decreasing the harvest temperature by picking the cherries in early morning increased the product yield. The effect of applying a 56° water spray to cherries on the tree to lower the harvest temperature of the fruit is discussed. A time relationship study of temperature, firmness and soluble solids of fruit on the tree over a 48 hour continuous period is discussed.

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Introduction

Normally over 150,000 tons of red tart cherries are produced annually in the Great Lakes and Northwest regions of the United States. Over 95% of the crop is processed as pitted cherries within 24 hours after harvest.

The quality and product yield[3] of processed cherries are affected by the amount of bruising the fruit receives during harvesting, handling and processing operations. Recurrent bruising often causes serious losses in quality and product yield (Whittenberger, et. al., 1964). Moreover, the amount of bruising determines whether cherries gain or lose weight when soaked in water (Whittenberger et. al., 1953, 1964). Since cherries are bought and sold by weight, excessive orchard bruising may penalize the grower by reducing the weight of fruit prior to its purchase by the processor. At the cannery, rebruised fruit may continue to lose weight at the processors's expense.

Cherries, do, however, largely recover from a single bruise if given sufficient time (Parker et. al., 1966, LaBelle et. al., 1964) and regain much of their original firmness. Parker et. al. (1966) found also that a holding or aging period increases the pitter efficiency[4] of unbruised cherries, although cherry firmness may remain unchanged.

It has been shown that bruise level, soak time and temperature have an important influence on the quality, product yield and pitter efficiency of tart cherries. However, more information is needed on the specific effect of bruise level and harvest temperature and optimum values of soak time and temperature. For these reasons, the present study during the 1966 season was undertaken in the major fruit producing areas of Michigan at Hartford, Bailey and Traverse City.

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[3]Product yield is the ratio of the harvest weight and the weight after pitting expressed as a percent.

[4]Pitter efficiency is the ratio of the weight of cherries before and after pitting expressed as a percent.

Specific Objectives

This study was undertaken with the following specific objectives:

1. Study the effect of bruise level on product yield, and pitter efficiency and other related factors such as firmness and soluble solids.
2. Study values of soak time and temperature for cherries necessary to optimize pitted yield.
3. Study the effect of the temperature of the cherry at harvest and methods of reducing this temperature in the orchard.

Experimental Procedure

Effect of Bruising For determining the effect of buise level and soak time on product yield and pitter efficiency, cherries were carefully hand harvested and taken to the processing plants within 15 minutes. There the cherries were given bruising treatments and soaked in commercial soak tanks at 54°F. Bruiselevels of 0-X, 1-X, 2-X, and 3-X were used (the value of X refers to the number of 30 inch free drops on a hard surface and the 0-X is an unbruised check sample). Every two hours, firmness and percent soluble solids were measured on 20 cherries of each sample, and 100 cherries were used to measure product yield and pitter efficiency. A complete experiment was made over an eight hour period and was repeated on four consecutive days.

Pitting was done with a six needle hand pitter which operates on the same principle as a large commercial pitter (Figure 1). Firmness was measured using a PL meter. Both these instruments are described by Parker (1966). The PL meter uses the creep displacement of a 20 gram, 0.203 inch diameter dial gage probe into the cherry at the calyx end over a specified time interval as a measure of firmness. A 30 second time interval was used for these tests. Percent soluble solids was measured with a hand refractometer.

To measure the effect of soak temperature the water and cherries in a one-half ton soak tank were cooled to 39°F using crushed ice in the circulation system (Figure 2). Samples of 100 cherries were withdrawn at 2 hour intervals for an eight hour period and measurements of product yield and weight loss were made and compared to values for cherries in the control tank at 55°F.

Effect of Harvest Temperature The effect of the fruit temperature at harvest on fruit properties was measured using cherries on the tree. Product yield was measured by selecting cherries for tests at different times during the day and night using natural temperature variations. Cherries also were cooled by spraying them two minutes with an air blast orchard sprayer using 56°F water (Figure 3). Thermocouples were placed in selected cherries and in the air within the tree canopy to measure temperature change. A study was also made over a 48 hour continuous period in which temperature change, soluble solids, firmness and detachment force of the fruit were measured (Figure 4).

Results

There are no two identical years of cherry behavior. These results are for the 1966 season only, but indicate trends that will probably recur in crops of following years.

Effect of Bruise Level The effect of bruising on all fruit properties was most pronounced at the beginning of the soak period. In Figure 5, product yield based on pre-soak weight and pitter efficiency based on the weight before pitting are shown for four levels of bruising.

Curves on the graphs were fit using least square polynomial and regression programs and the equations are given on the graphs. From the derivatives of these equations, optimum estimated soak times are given in Table 1. Since cherries are bought and sold by weight, the product yield is the most important factor. It includes weight changes during unloading, soaking, and conveying cherries at the cannery, as well as pitter efficiency.

Product yield and pitter efficiency were both closely related to bruise level at the beginning of the soak period and were lowered as much as 5% for a 3X bruise. However, bruised cherries recovered quickly and reached their optimum values of product yield and pitter efficiency after about 4 hours of soaking. Corresponding values for unbruised cherries were lower at this time and did not reach a maximum value until after 6 hours of soaking. Even then,values for unbruised cherries were still lower than the four hour value for 1X cherries after 4 hours soaking. After 8 hours of soaking, however, unbruised cherries gave a product yield 5% higher than that of 3X cherries, although the two samples showed only a slight difference in pitter efficiency.

These results show that product yield is a definite combination of bruise level and soak time and that a combination of a 1-X bruise and a 4.5 to 5 hour soak period apparently gives optimum pitter efficiency values. Apparently, a small amount of bruising is necessary to give the best pitting results and excessive firmness may be as undesirable as excessive bruising.

From the derivatives of the data fitting equations in Appendix A the following soak times in hours were calculated corresponding to maximum values of product yield: 0-X,-not applicable; 1-X,-4.87; 2-X,-6.66; and 3-X,-4.16 hours. For pitter efficiency the optimum soak time values were: 0-X,-not applicable; 1-X,-4.92; 2-X,-4.93; and 3-X,-5.93 hours. See Figure 5.

The PL meter proved to be an effective means of measuring firmness.[5] However, firmness values shown in Figure 5, were not related directly to product yield or pitter efficiency except at the time of initial bruising. Generally, it is believed that cherries get firmer when soaked in water. This is not generally true as shown by the data in Figure 5. Cherries at all bruise levels decreased in firmness during the first few hours except the 3-X group which increased. In the last few hours firmness increased except the 3-X cherries which decreased. The 3-X sample remained least firm of all bruise levels during the entire soaking period.

Soak times corresponding to maximum values of firmness were also calculated. These values were: 0-X,-4.68; 1-X,-0.37; 2-X,-2.73; 3-X,-(4.36 - minimum value) in hours. See Figure 5.

Soluble solids of the cherries decreased about the same amount (concentration basis) in all samples during the soak period (Figure 5). The decrease was most rapid in the most severely bruised fruit. It should be pointed out, however, that bruised cherry tissues lost considerably more soluble solids (weight basis) into the soak water than do unbruised tissues (Whittenberger et. al., 1953). On the other hand, unbruised tissues absorb relatively large amount of water which dilutes the soluble solids. For different reasons, therefore, the concentration

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[5] Firmness as used here is a measure of the physical stiffness of the cherry measured by a probe on the calyx end.

of soluble solids in both bruised and unbruised tissues may decrease to the same extent during a soak period.

Effect of Soak Temperature Lowering the soak temperature from 55° to 39°F did not substantially change product yield, quality or scald content of cherries (Figure 6). Values of product yield and weight change were similar for both soak temperature with the exception that the colder soak appeared to prevent slightly less weight loss during the 8 hour soak period.

This indicates there is no advantage of using a 39°F soak temperature over a 55°F temperature. In Fact, PL measurements showed that 39° cherries actually softened while those in 55°F became slightly firmer. Optimum soak times for both temperatures are given in the paragraph below. The two factors which seem to influence pitter efficiency are: (1) loosening of the pit and (2) firming and aging of the flesh. The pits of cherries in 39° water became loose and easily separable in 15 minutes while pits of cherries in 55° water did not become loose until they were in the water for two and a half hours. Enzyme action which causes firming was substantially retarded by the 39° temperature since little firming or aging of the flesh took place.

Soak time corresponding to maximum values of product yield were: 55°F,-5.93 and 39°F,-5.43 hours. For maximum weight loss these times were: 55°F,-3.40 and 39°F,-2.71 hours.

The cherries were soaked an additional 15 hours after which they were processed in a regular commercial operation. Both lots remained free of scald, gave high product yields and received "A" grades. The original cherries were machine harvested and water handled but were not rebruised during unloading at the cannery.

Effect of Harvest Temperature Lowering the harvest temperature of cherries as shown in Figure 7 from 75°F to 55°F increased the product yield of the fruit. The temperature effect was almost directly related to product yield down to temperatures of about 60°F. Lowering the temperatures below 55°F did not provide any further increase in pitted yield in this test. Using the equations in Appendix A, optimum harvest temperatures of 59.6°F and 59.2°F were calculated for pitted yield and weight change respectively.

The actual variation of temperature, soluble solids and firmness for cherries on the tree is shown in Figure 8. All variables follow roughly a sinusodial pattern over a 24 hour period. During the testing period the temperatures were abnormally cool for this time of year. The lowest temperatures occurred at 6 AM and the highest of temperatures occurred at 2 PM. Soluble solids and firmness reached maximum values at about 12 midnight and 11:30 PM respectively and minimum values at 12 noon and 11:30 AM respectively which lead similar values for temperature by about four hours. (Using least squares fit for $y = a + bt + c\sin(nt/6)$.

Lowering cherry temperature using an air blast orchard sprayer was very promising as shown in Figure 9. Temperature drop in the cherry as much as 20°F was possible within 6 minutes after the application of a 2 minute spray. Cherries #3 and #4 at the sides of the tree dropped 10° in temperature. These cherries were initially cooler since they were shaded. Thus due to this combination of location and shading, the temperature of cherries over one-half of the tree was reduced to about 68°F. The spray had little effect on cherry #2 on the opposite side of the tree.

Conclusions

Under 1966 conditions in Michigan, the following conclusions can be made:

1. A combination of a 1-X bruise level and a 4.5 to 5 hour soak period at 54°F resulted in optimum values of product yield of tart cherries. Maximum losses in cherries occurred immediately after bruising.
2. Firmness of the fruit measured using the PL meter was directly related to bruise level.
3. Since bruise level is not directly related to product yield or pitter efficiency, except at the beginning of the soak period, firmness measurements alone can not be used to predict product yield. It is also necessary to specify the length of soak time and the degree of bruising.
4. Lowering the soak temperature from 55°F to 39°F had no beneficial effect on increasing pitted yield, or quality of mechanically harvested cherries.

5. Lowering the harvest temperature increased the pitted yield. However at temperatures below $60^{o}F$ no corresponding increase in pitted yield resulted.
6. Temperature, soluble solids and firmness of cherries on the tree followed a sinusodial pattern over a 24 hour period. Fifteen degree variations in temperature occurred during this period.
7. Use of an air blast sprayer charged with $56^{o}F$ water effectively lowered the temperature of cherries $15^{o}F$ on one-half of the tree within six munutes. Cherries regained their orginial temperature within one-half hour. Cherries on the opposite side were cooled very little. Coverage from both sides would be necessary.

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APPENDIX-A. Polonomial equationsused for data curve fitting in Figures 5, 6 and 7.

Figure 5

Pitted Yield (1X) = $84.71 + 0.941t - 0.096t^{2*}$
Pitted Yield (2X) = $84.17 + 0.738t - 0.055t^2$
Pitted Yield (3X) = $81.06 + 1.145t - 0.138t^2$

Pitter Efficiency (1X) = $84.67 + 1.038t - 0.1054t^2$
Pitter Efficiency (2X) = $83.59 + 1.21t - 0.123t^2$
Pitter Efficiency (3X) = $80.87 + 2.099t - 0.177t^2$

Firmness (0X) = $25.70 + 2.52t - 0.269t^2$
Firmness (1X) = $38.47 - 0.0686t - 0.0964t^2$
Firmness (2X) = $45.83 + 1.38t - 0.252t^2$
Firmness (3X) = $64.01 - 3.23t + 0.379t^2$

Figure 6

Pitter Efficiency ($55^{\circ}F$) = $84.58 + 0.695t - 0.059t^2$
Pitter Efficiency ($39^{\circ}F$) = $84.88 + 0.614t - 0.0564t^2$

Weight Change ($55^{\circ}F$) = $-0.128 - 0.157t + 0.0231t^2$
Weight Change ($39^{\circ}F$) = $-0.044 - 0.103t + 0.019t^2$

Figure 7

Pitted Yield = $0.491 + 1.167T - 0.0099T^{2**}$
Weight Change = $-0.313 + 0.992T - 0.0084T^2$

* t is experimental time in hours.
** T refers to temperature in degrees F.

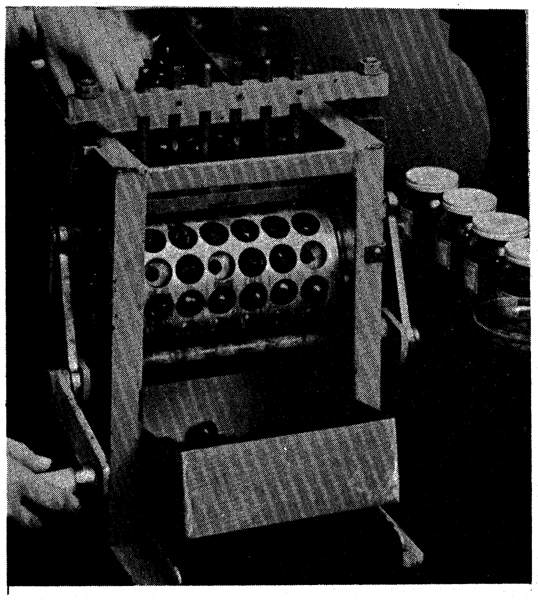


Figure 1. Six needle hand pitter used to measure product yield and pitter efficiency

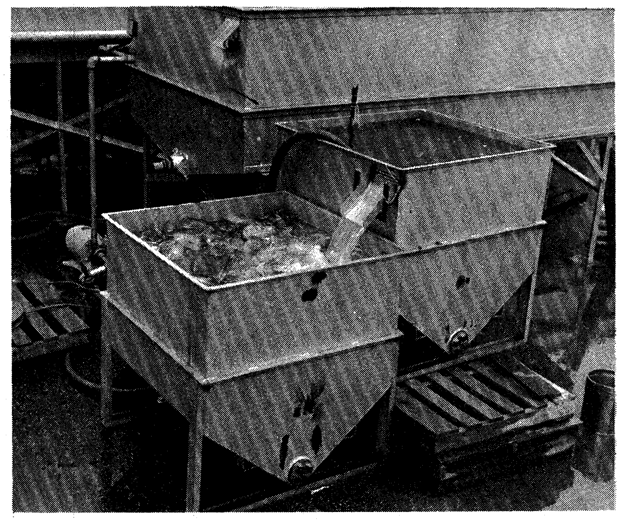
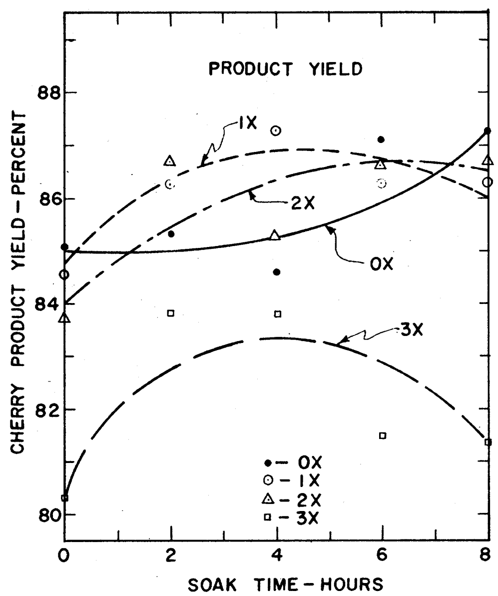


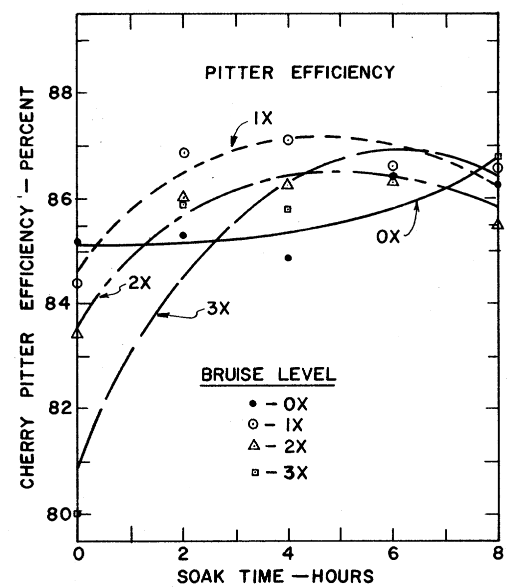
Figure 2. Soak tanks at Bailey, Michigan

Figure 3. Spraying cherries on the tree with an orchard blast sprayer to reduce cherry temperature

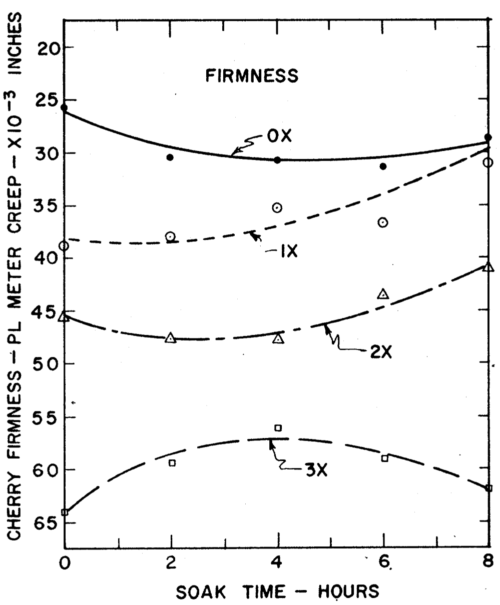
Figure 4. Measurement of cherry properties on the tree



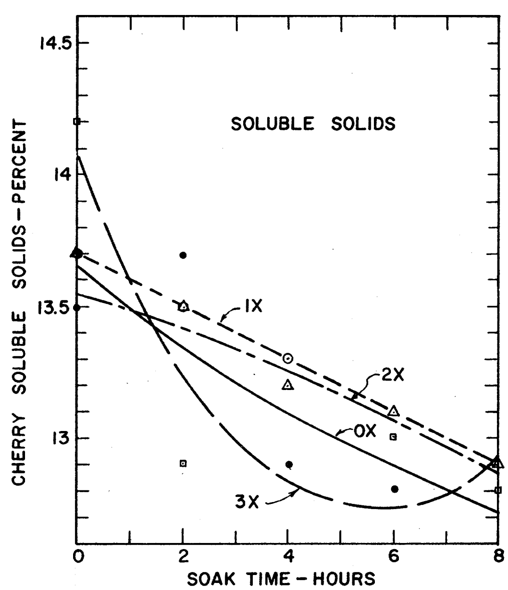
a. Product yield vs soak time.



b. Pitter efficiency vs soak time.



c. Firmness vs soak time.



d. Soluble solids vs soak time.

Figure 5. Effects of bruise level and soak time at 54°F. on red tart cherries.

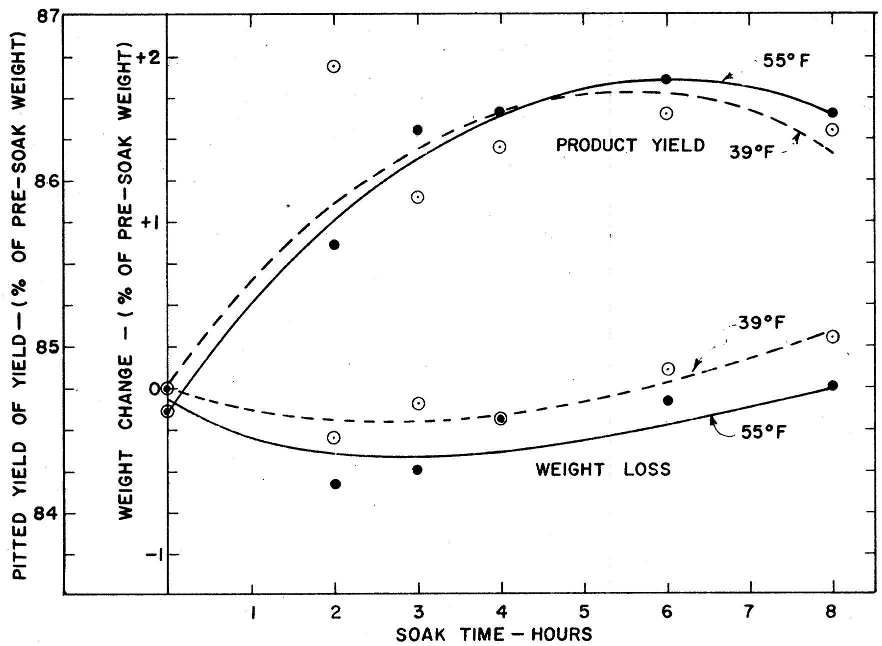


Figure 6. Cherry pitted yield and weight loss vs soak time at temperatures of 55°F. and 39°F.

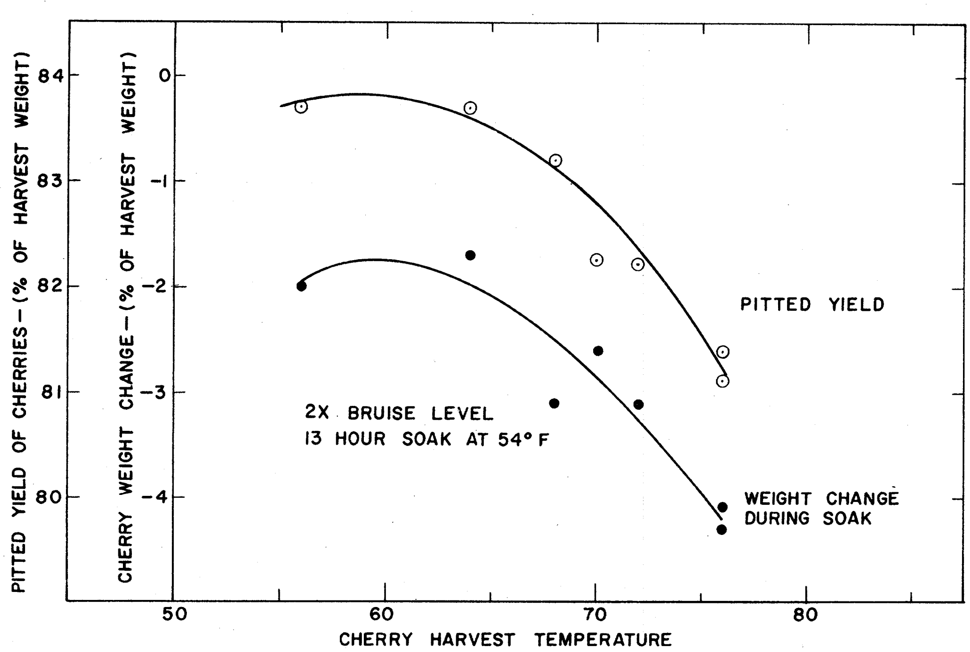


Figure 7. Effect of cherry harvest temperature in degrees F. on pitted yield and weight change during soaking at 54°F.

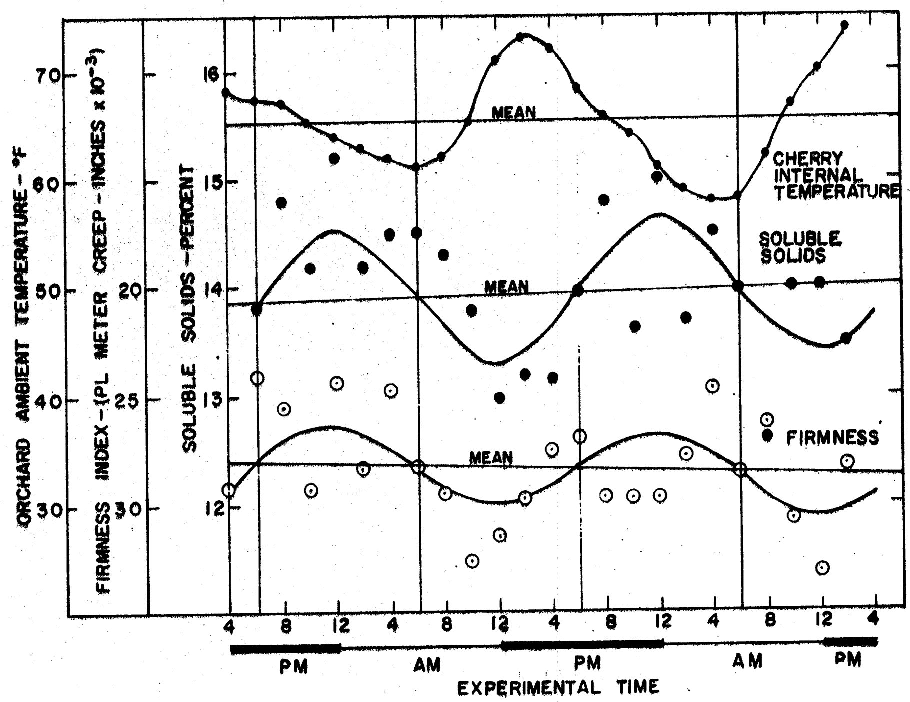


Figure 8. Temperature, firmness and soluble solids variation of cherries on the tree over a 48-hour continous period.

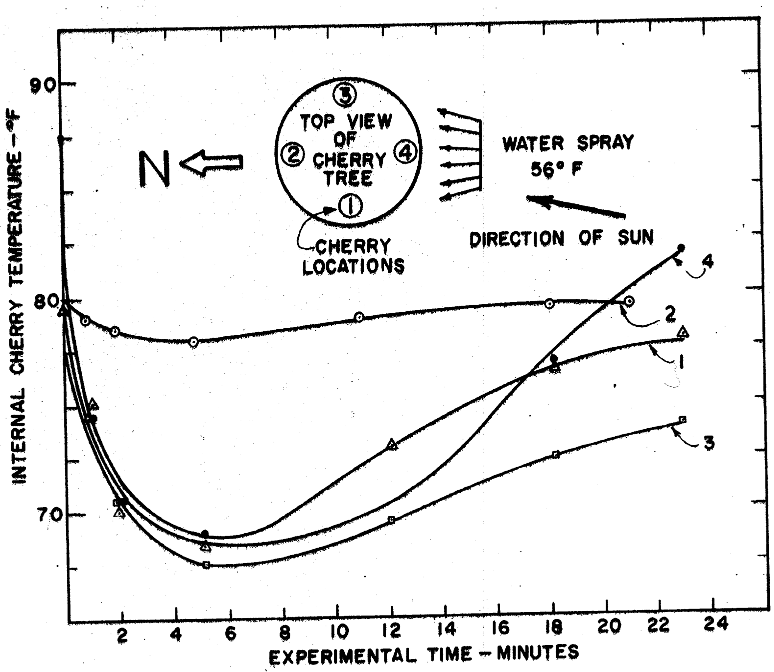


Figure 9. Effect of water spray in reducing the internal temperature of cherries on the tree.